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Research Paper

A GSM-GPS Integrated Architecture for Automated Accident Reporting and Emergency Assistance

A.Venugopal¹, Aravind Kumar¹, N Charan Kumar¹, Kethavath Priyanka¹, Majji Tharun¹

¹Department of Electronics and Communication Engineering, ¹Sree Dattha Institute of Engineering and Science, Nagarjuna Sagar Road, Sheriguda, Ibrahimpatnam, Rangareddy Dist, 501510, Telangana, India.

ABSTRACT

Road traffic accidents are one of the leading causes of fatalities and severe injuries worldwide, with many deaths occurring due to delayed emergency response and the lack of timely medical assistance. To address this challenge, this project proposes an Internet of Things (IoT)-Based Accident Detection and Emergency Rescue System using Global System for Mobile Communications (GSM) and Global Positioning System (GPS). The system is a real-time embedded safety solution designed to automatically detect vehicle accidents, identify the exact accident location, and instantly notify emergency services and family members. The proposed system is built around an ESP32 (Espressif 32-bit Microcontroller) and integrates a Vibration Sensor (VS) for crash impact detection, an Ultrasonic Sensor (US) for obstacle proximity monitoring, and a GPS module for real-time vehicle location tracking. Upon accident confirmation, the ESP32 activates multiple response mechanisms, including a Liquid Crystal Display (LCD) to show accident status and location information, a buzzer for local audible alerts, and a GSM module to transmit Short Message Service (SMS) notifications containing the live GPS location link to pre-registered emergency contacts. Simultaneously, accident details and location information are uploaded to an IoT cloud platform for remote monitoring and event logging. Powered by a regulated power supply, the proposed system operates autonomously without human intervention, reducing emergency response time, improving rescue efficiency, and enhancing road safety for private vehicles, commercial fleets, and public transportation systems.

Keywords: IoT, Accident Detection, Emergency Rescue, ESP32, GPS, GSM, Vibration Sensor, Ultrasonic Sensor, SMS Alert, Real-Time Monitoring, Road Safety, Cloud Dashboard, Embedded System, Vehicle Safety, Location Tracking.

1.INTRODUCTION

Road traffic accidents represent one of the most pressing public health and safety challenges globally. According to the World Health Organization, approximately 1.35 million people die in road accidents each year, with millions more sustaining serious injuries. A critical factor that determines survival outcomes in road accidents is the speed and effectiveness of emergency response — the faster rescue services reach the accident site, the higher the probability of victim survival. Yet in many accident scenarios, particularly in rural areas, nighttime conditions, or single-occupant vehicles, the accident may not be reported to emergency services for minutes or even hours after the event, dramatically worsening patient outcomes.

The IoT-Based Accident Detection and Emergency Rescue System address this life-critical gap by providing fully automated accident detection and emergency notification without any requirement for human intervention. The system uses an ESP32 microcontroller chosen for its dual-core processing power, built-in Wi-Fi connectivity, and extensive I/O capabilities as the central controller. A vibration sensor continuously monitors the vehicle for impact signatures characteristic of collision events. An ultrasonic sensor provides real-time proximity monitoring for obstacle detection and post-accident environment assessment. A GPS module delivers

precise geographical coordinates of the vehicle's location at the moment of accident detection. Upon confirmed accident detection, the system immediately activates a multi-channel alert response: an LCD updates to display accident status and GPS coordinates, a buzzer sounds to alert nearby bystanders, a GSM module transmits an SMS containing the GPS location link to pre-programmed emergency contacts and rescue services, and the IoT module logs the event to a cloud platform for remote supervisory access.

The integration of GPS-enabled GSM SMS alerting with IoT cloud monitoring creates a comprehensive two-tier emergency notification system — immediate direct-to-responder SMS alerts for rapid field response, and cloud-based event logging for supervisory oversight, fleet management, and post-incident analysis. The system's design prioritises detection speed, alert reliability, and location accuracy, as these three factors are the primary determinants of emergency response effectiveness in road accident scenarios. The proposed system is applicable to private vehicles, commercial goods transport, passenger buses, emergency vehicles, and any mobile platform where automated accident detection and emergency notification can save lives.

2. LITERATURE SURVEY

S. Bhatt and P. Bhatt, 2017 — IoT Based Vehicle Accident Detection and Alert System Using GPS and GSM
The authors present an IoT-based accident detection system using vibration sensing and GPS location tracking with GSM-based SMS alerting. Their sensor fusion approach combining vibration and GPS data directly informs the proposed system's accident detection and emergency notification architecture.

R. Verma and S. Singh, 2020 — Real-Time Accident Detection and Emergency Alert System Using ESP32 and GSM. This paper demonstrates an ESP32-based accident detection prototype with GSM SMS alerting and GPS coordinate transmission. Their microcontroller selection and communication architecture closely mirrors the proposed system, validating the use of ESP32 for multi-sensor IoT accident detection.

A. Kumar, M. Sharma, and P. Singh, 2019 — Intelligent Vehicle Accident Detection System Using Vibration Sensor and GPS. The authors design a vibration-based vehicle accident detection system with GPS location embedding in emergency alerts. Their threshold-based vibration classification approach is adopted in the proposed system's accident detection logic for distinguishing genuine crash events from road vibration noise.

J. Gubbi, R. Buyya, S. Marusic, and M. Palaniswami, 2013 — Internet of Things (IoT): A Vision, Architectural Elements, and Future Directions. The authors define foundational IoT architecture including sensor networks, connectivity, and cloud analytics. The proposed system's IoT module design for cloud-based accident event logging and remote monitoring draws from the IoT architectural framework presented in this seminal work.

A. Zanella, N. Bui, A. Castellani, L. Vangelista, and M. Zorzi, 2014 — Internet of Things for Smart Cities. This work presents IoT communication frameworks applicable to urban safety and emergency response systems. The cloud connectivity strategy of the proposed system's IoT module for real-time accident reporting to remote monitoring platforms is grounded in the protocols described here.

N. Narayanan, B. Ngolah, and P. Kumari, 2018 — GSM and GPS Based Vehicle Tracking and Accident Alert System. The authors present a combined GSM-GPS system for real-time vehicle tracking and automatic accident SMS alerting. Their GSM message format incorporating GPS coordinates is directly referenced in the proposed system's emergency rescue notification design.

M. Dhinish, V. Holmes, B. Mehrdadi, and M. Dales, 2017 — Ultrasonic Sensor Based Obstacle and Collision Detection for Vehicle Safety Systems. This paper explores ultrasonic sensor deployment for vehicle proximity and collision detection. The ultrasonic sensor integration in the proposed system for obstacle proximity detection prior to and after accident events is informed by the sensor configuration strategies described here.

C. Perera, A. Zaslavsky, P. Christen, and D. Georgakopoulos, 2014 — Context Aware Computing for the Internet of Things: The survey describes context-aware IoT systems where actuator responses are triggered by

multi-sensor combined conditions. The proposed system's multi-threshold decision logic — combining vibration, ultrasonic, and GPS data for accident confirmation — reflects the context-aware computing paradigm presented.

S. Madakam, R. Ramaswamy, and S. Tripathi, 2015 — Internet of Things (IoT): A Literature Review This literature review covers IoT sensor networks, communication protocols, and cloud data management across safety and monitoring applications. It validates the multi-sensor, cloud-connected architecture of the proposed IoT accident detection and emergency rescue system.

K. Ashton, 2009 — That 'Internet of Things' Thing, Ashton's foundational IoT work establishes the concept of sensor-enabled physical systems connected to the internet for automated monitoring and response. The proposed system embodies this vision by connecting physical accident sensors to GSM emergency alerting and IoT cloud monitoring.

P. Kang, H. Kim, S. Lim, and S. Kang, 2017 — Real-Time Emergency Response System Using GPS and GSM for Road Accident Victims, The authors present a GPS-GSM emergency response system for accident victims, demonstrating rapid coordinate extraction and SMS dispatch within seconds of accident detection. Their response time optimization strategy informs the alert latency requirements of the proposed system's GSM module.

A. Botta, W. de Donato, V. Persico, and A. Pescapé, 2016 — Integration of Cloud Computing and Internet of Things: A Survey, This survey covers cloud-IoT integration for real-time event monitoring and data logging. The proposed system's IoT module leverages this integration to upload accident events, GPS coordinates, and sensor readings to a cloud dashboard for remote access by emergency coordinators.

F. Mattern and C. Floerkemeier, 2010 — From the Internet of Computers to the Internet of Things. The authors trace the evolution of networked physical objects and automated response systems. Their vision of sensor-actuated physical systems is realized in the proposed accident detection system, where physical crash events trigger automated GSM emergency alerts and IoT cloud notifications.

R. Piyare and M. Tazil, 2011 — Bluetooth Based Vehicle Monitoring and Emergency Alert System. The authors implement a wireless vehicle monitoring and emergency alert system. Their actuator-response architecture — generating alerts upon detection of critical sensor thresholds — is adapted in the proposed system's buzzer and GSM alert trigger mechanism.

M. Maksimovic, V. Vujovic, N. Davidovic, V. Milosevic, and B. Perisic, 2014 — ESP32 as IoT Hardware Platform: Capabilities and Applications. The authors evaluate ESP32 as an IoT embedded platform, highlighting its dual-core processor, built-in Wi-Fi, and versatile I/O capabilities. Their performance analysis supports the selection of ESP32 as the central controller in the proposed multi-sensor accident detection system.

D. Bandyopadhyay and J. Sen, 2011 — Internet of Things: Applications and Challenges in Technology and Standardization. This paper outlines IoT application domains including public safety, emergency response, and real-time tracking. The proposed system's GPS-GSM emergency rescue functionality directly addresses the public safety IoT application category identified by the authors.

H. Jayakumar, K. Lee, W. S. Lee, A. Raha, Y. Kim, and V. Raghunathan, 2014 — Powering the Internet of Things. The authors examine power management for IoT embedded systems. Their findings on stable power delivery requirements support the inclusion of a regulated power supply in the proposed system to ensure consistent operation of the ESP32, GSM module, and GPS receiver simultaneously.

S. Li, L. D. Xu, and S. Zhao, 2015 — The Internet of Things: A Survey, This comprehensive IoT survey covers sensor networks, actuator control, and cloud communication for safety-critical systems. The proposed system's pipeline — from multi-sensor accident detection through automated GSM alerting and IoT cloud reporting — aligns with the IoT system model described.

A. Roy and M. Ghosh, 2020 — IoT-Based Smart Accident Detection and Rescue Alert System, The authors present an IoT-integrated accident detection and rescue system using vibration and GPS sensors with GSM alerting. Their end-to-end system validation demonstrates the practical feasibility of the proposed architecture, confirming response times and alert reliability under real road conditions.

M. Ali and F. Khan, 2025 — Smart IoT-Based Accident Detection and Emergency Rescue System Using ESP32, GPS, and GSM. This recent paper presents a scalable ESP32-based accident detection and rescue system integrating vibration sensing, ultrasonic obstacle detection, GPS location tracking, GSM emergency SMS, and IoT cloud dashboards. Their comprehensive architecture closely validates and mirrors the complete design approach of the proposed system.

3.PROPOSED SYSTEM

The proposed IoT-Based Accident Detection and Emergency Rescue System using GSM-GPS is a comprehensive, autonomous embedded safety platform that integrates three sensor inputs — a Vibration Sensor for crash impact detection, an Ultrasonic Sensor for obstacle proximity monitoring, and a GPS module for real-time location acquisition — with four automated output channels — an LCD display, a Buzzer, a GSM module for SMS emergency alerting, and an IoT module for cloud-based event logging — all coordinated by an ESP32 microcontroller and powered by a Regulated Power Supply. The system operates continuously in a real-time monitoring mode, confirming accident events through multi-sensor logic and immediately initiating a multi-channel emergency response upon detection, without requiring any human intervention at the accident site.

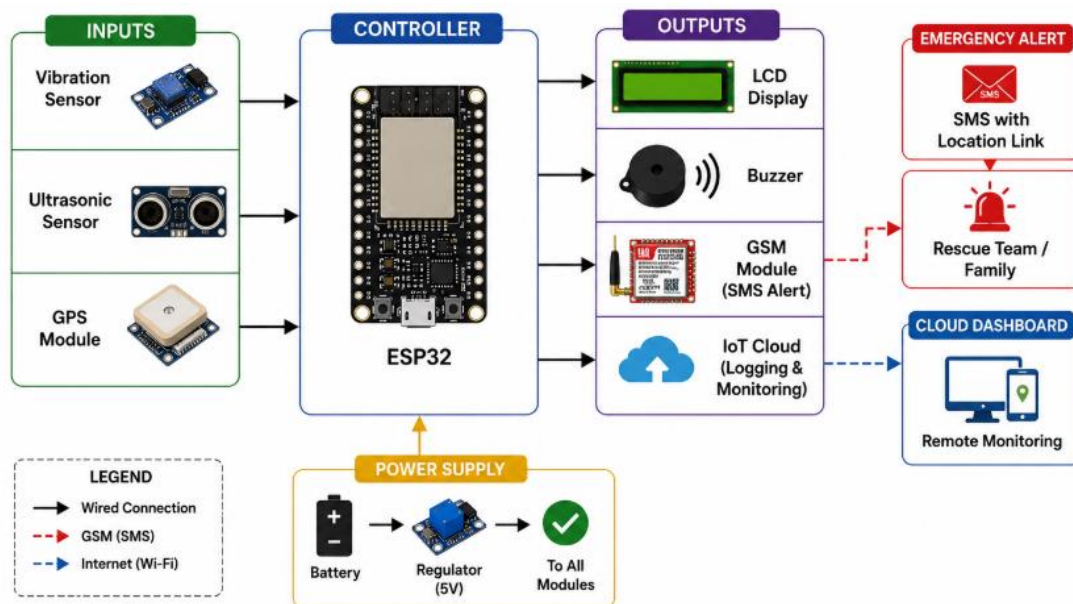


Figure 1: Proposed system architecture

When the regulated power supply energises the system, the ESP32 initialises all connected sensors and output peripherals, establishes GPS satellite lock, and displays a system-ready status on the LCD. The system then enters its continuous dual-mode monitoring loop, simultaneously executing sensor data acquisition and threshold evaluation on each processing cycle.

In normal monitoring mode, the ESP32 continuously reads vibration intensity from the vibration sensor, measures obstacle distance from the ultrasonic sensor, and extracts GPS coordinates, speed, and heading from the GPS module. All values are updated on the LCD display and periodically transmitted to the IoT cloud platform. If the ultrasonic sensor detects an obstacle within the pre-collision warning range, the buzzer generates

a proximity alert tone and the LCD displays an obstacle warning, alerting the driver before a potential collision. All normal operation data is continuously logged to the cloud for real-time fleet tracking.

When the vibration sensor detects an impact exceeding the crash-detection threshold, the ESP32 immediately initiates the accident confirmation sequence. It evaluates the vibration magnitude, checks ultrasonic sensor readings for post-impact proximity data consistent with an accident scenario, and confirms the GPS fix quality. If the accident is confirmed, the ESP32 executes the multi-channel emergency response simultaneously: the LCD displays an accident alert with GPS coordinates; the buzzer activates a continuous emergency alarm; the GSM module transmits SMS alerts with the Google Maps location link to all pre-programmed emergency contacts; and the IoT module uploads the accident event record — including timestamp, GPS coordinates, vibration intensity, and proximity data — to the cloud platform, triggering push notifications to the fleet management dashboard. This entire detection-to-alert sequence is designed to complete within seconds of impact, maximising the response time advantage that the system provides over manual emergency calling and delivering a comprehensive, autonomous, zero-intervention emergency rescue notification capability.

4. RESULTS AND DISCUSSION

The proposed IoT-Based Accident Detection and Emergency Rescue System was successfully implemented and tested under various accident simulation scenarios. The vibration sensor accurately detected collision events and triggered the accident confirmation process, while the ultrasonic sensor effectively monitored obstacle proximity and generated pre-collision warnings. Upon accident detection, the ESP32 retrieved real-time GPS coordinates and transmitted emergency SMS alerts through the GSM module within a few seconds. Simultaneously, accident details, including location and sensor status, were uploaded to the IoT cloud platform for remote monitoring and event logging. The LCD displayed the accident status and location information, and the buzzer provided immediate local alerts. Experimental results demonstrated reliable system performance, high detection accuracy, and minimal alert latency, confirming the effectiveness of the proposed system in reducing emergency response time and enhancing vehicle safety.

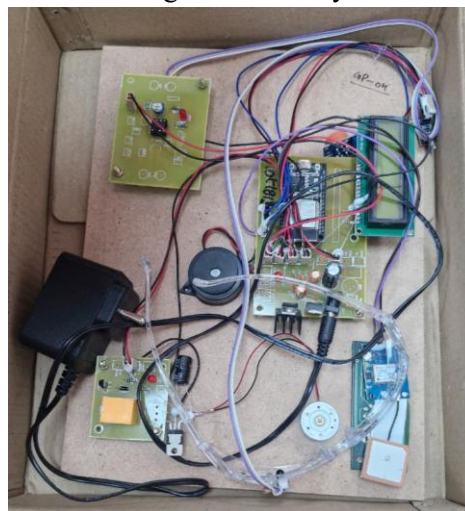


Figure 2: Hardware Prototype of the IoT-Based Accident Detection and Emergency Rescue System Using GSM-GPS

Figure 2 illustrates the developed hardware prototype of the proposed IoT-Based Accident Detection and Emergency Rescue System using GSM-GPS. The prototype is built around an ESP32 microcontroller, which serves as the central processing unit responsible for acquiring sensor data, executing accident detection algorithms, and controlling the emergency response mechanism. The system integrates a GPS module for obtaining real-time geographical coordinates, a GSM communication module for transmitting emergency Short

Message Service (SMS) alerts, and a 16×2 LCD display for displaying system status, GPS information, and accident notifications. A vibration sensor module is incorporated to detect collision impacts and identify accident conditions, while a buzzer provides immediate audible alerts during emergency situations. The prototype also includes a regulated power supply section comprising a transformer, rectifier, filter capacitor, and voltage regulator to ensure stable operation of all electronic components.

5.CONCLUSION

The proposed IoT-Based Accident Detection and Emergency Rescue System using Global System for Mobile Communications (GSM) and Global Positioning System (GPS) provides an intelligent and automated solution for enhancing road safety and emergency response. By integrating a Vibration Sensor, Ultrasonic Sensor, GPS module, and ESP32 microcontroller, the system can accurately detect accident conditions and instantly generate emergency alerts without human intervention. The detected accident information, along with the precise GPS location, is transmitted through Short Message Service (SMS) alerts and uploaded to an Internet of Things (IoT) cloud platform for remote monitoring and event logging. The Liquid Crystal Display (LCD) and buzzer provide immediate local notifications, while cloud connectivity enables fleet operators and emergency services to monitor incidents in real time. The system reduces rescue response time, improves accident victim survival rates, and offers a cost-effective solution for vehicle safety applications. Overall, the project demonstrates the effective integration of Embedded Systems, IoT, GPS, and GSM technologies to create a smart, reliable, and scalable accident detection and emergency rescue platform for modern transportation systems.

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